Testimony Before the U.S. House Education and Labor Sub-Committee on
Higher Education, Lifelong Learning and Competitiveness
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Introduction

To Chairman Hinojosa and members of the Sub-Committee, I would like to express my appreciation for the opportunity to comment on the growing need for graduates in science, technology, engineering and mathematics (STEM) disciplines, some of the steps we are taking at California Polytechnic State University (Cal Poly) to address this need, and additional policy measures that might be implemented at the federal level to help us address this issue at the state and local level.

Background

The United States and particularly California have enjoyed significant economic gains over the past half century. Much of this growth has come from investments in science, engineering and technology education and research and from creation of the world's pre-eminent universities. Thanks to investments since WWII, we have become the world leader in scientific and technological discovery and innovation, to the great benefit of our standard of living and quality of life. Our leadership position is now being challenged by rapid progress in science and technology in other industrialized nations, fueled by strong rates of public investment in education and research, including establishment of first-class universities.

According to the National Science Foundation's biennial report on science and engineering, natural science and engineering doctoral degree production is either not increasing or declining in Western nations like the U.S., United Kingdom and Germany, while it is increasing in China, South Korea and Japan (NSB 2006:2-6). The proportion of U.S. bachelor's degrees conferred in science and engineering disciplines remained relatively constant over the past two decades (about one-third of the total), but the proportion of degrees granted in engineering declined from seven percent to five percent during that period (NSB 2006:2-4). The report documents continued low rates of baccalaureate degree completion among underrepresented minorities in the U.S. For example, only 10 percent of Hispanics aged 25-29 had completed a baccalaureate degree in 2003, compared to 34 percent of whites (NSB 2006:2-5). This is a particularly worrisome statistic for California, with its large Hispanic population. A 2002 report estimated that "less than five percent of [California] Latino high school students graduate with college-ready skills" (CCST 2002:45). We have seen early warning signs of the potential consequences of the state's changing demographics for STEM education. In the 1990s, the number of California baccalaureate degrees in mathematics and engineering experienced a 13 percent decline (CCST 2002:67).

Recently, a number of celebrated reports have called for renewed investment in STEM education to reverse decline in the nation's relative strength in science and technology and regain our technological leadership. To cite just a few examples:

- In 2005 a blue ribbon committee of the National Academies, responding to a congressional charge, issued the report, "Rising Above the Gathering Storm." It recommended key steps the nation must take to preserve its capacity to compete technologically and economically in an increasingly competitive global environment. Two of the four main recommendations in this report called upon the nation to expand its investment in STEM education – from kindergarten through graduate school.

- In two other recent national reports, the Business-Higher Education Forum highlighted the critical role that K-12 science and mathematics education play in preparing students to pursue STEM careers:

  - the 2005 report, "A Commitment to America's Future: Responding to the Crisis in Mathematics and Science Education," and
  - the 2007 report, "An American Imperative: Transforming the Recruitment, Retention, and Renewal Of Our Nation's Mathematics and Science Teaching Workforce."

  These reports call upon the nation to make it an urgent national priority to strengthen K-12 science and mathematics education and in particular to invest in renewal of the science and mathematics teacher workforce.

- The California Council on Science and Technology raised similar concerns in several reports over the past decade:

  - the 1999 "California Report on the Environment for Science and Technology,"
  - the 2002 "Critical Path Analysis of California's S&T Education System," and
  - the 2007 "Critical Path Analysis of California's Science and Mathematics Teacher Preparation System."

  These reports documented strong continuing demand for science and technology workers in the California economy, an educational system that is failing to keep pace with this demand, and a K-12 science and mathematics teacher workforce that is being eroded by retirements and attrition without sufficient numbers of qualified replacement teachers.

Against the background of these reports, and with the assistance of other recent policy analyses, I would like to share several observations on the nature of the challenges we face and steps we can take to sustain and renew the California STEM workforce and ensure continued vitality of the State's economy.

- California will need a growing number of college-educated workers in coming decades, but we are falling short in meeting this demand. According to the Public Policy Institute of California, in 2020 75 percent of jobs will require at least some college but only 61 percent of the workforce will have achieved this level of education; 39 percent of jobs will require a

college degree but only 33 percent of workers will have attained one (Public Policy Institute of California 2005:1).

- Given projected rates of educational participation and achievement, the state will experience significant decline in per capita income. This is something that should concern all Californians. The National Center for Higher Education Management Systems has projected the future economic consequences of educational trends in the fifty states. California is projected to experience a $2,475 decline in per capita income by 2020 if we are not successful in increasing rates of educational participation and completion (Kelly 2005:25).

- Our ability to remain globally competitive as a state depends especially on our capacity for scientific and technical innovation. This in turn depends on our ability to engage students at a young age in the study of science and mathematics and to encourage them to embark upon college and university programs in STEM disciplines.

- We know that a strong K-12 educational system, with a curriculum and pedagogy responsive to the expectations of higher education and the workforce, is of critical importance in meeting our future STEM workforce needs.

- We also know from educational research that perhaps the single most important thing we can do to promote student involvement and success in STEM disciplines is to be sure that every K-12 student is taught science and math by competent, effective and inspiring science and math teachers while we continue to make needed investments in college programs, laboratories and faculty.

- But we face significant challenges:

  While progress has been made through the implementation of new educational standards in California and the other states, additional work is needed to ensure that K-12 educational systems are responsive to the expectations and requirements of colleges, universities and workplaces.

  The U.S. will need more than 280,000 new mathematics and science teachers by 2015 (BHEF 2007:4). We face a similar challenge in California. Over the next decade the state will need over 33,000 new mathematics and science teachers (CCST 2007:3). Even though the CSU and UC systems have ambitious plans to increase the number of science and math teachers they prepare, we have not yet caught up with demand. In 2005-06, 35 percent of new California science teachers and 40 percent of new math teachers were under-prepared (lacking even a preliminary teaching credential) (CCST 2007:22). Shortages of qualified science and math teachers are particularly acute at schools that have large percentages of students from minority and low-income backgrounds.

To ensure a continued adequate supply of science and technology innovators in California, we must continue to work to strengthen K-12 science and math programs and make it a special priority to prepare a new generation of science and mathematics teachers.

We must also invest in our universities and community colleges to increase access to STEM programs and to ensure that those programs are innovative, of high quality and responsive to rapid changes in science, technology and society. Weak STEM programs in K-16 education are now resulting in a shortage of advanced degrees in STEM fields. We will soon feel these effects in our universities and national laboratories.

Some Steps Being Taken at Cal Poly to Address the Crisis in STEM Education

Chancellor Reed's testimony to the committee describes in some detail steps being taken by the California State University to address the State's need for STEM graduates and in particular the need for qualified and inspiring science and mathematics teachers. I would like to share with the committee some steps that are being taken at one campus, in collaboration with partners in government and industry, to strengthen collaboration with the K-12 system and community colleges and to prepare additional science and mathematics teachers.

K-12/Higher Education/Industry Collaboration

In April of 2005, a P-16 Council was established in San Luis Obispo County. It has brought together leaders in K-16 education, business, and the community to address "critical gaps in educational achievement."

An early focus of the Council's work is an initiative on Mathematics and Science Education. It has identified the following goals:

1. Recruit and prepare well qualified P-16 teachers in science and mathematics.
2. Provide professional development for P-16 science and mathematics teachers.
3. Engage P-16 students in science and math and promote careers in science, technology, engineering and mathematics (STEM).
4. Serve as a repository/disseminator of best practices in P-16 science and mathematics Education. [1]

While this local effort is still in its early stages, we concur with the Business-Higher Education Forum and others that P-16 Councils can play critical roles in bringing together education, business and community stakeholders to achieve greater alignment of the educational segments and stronger preparation of graduates to meet the expectations of workplaces and higher education programs.

Teacher Recruitment and Preparation

Cal Poly has taken several important steps to address the state's need for science and mathematics teachers, including:

1. Development of a new undergraduate program that prepares chemistry majors for teaching careers in four years and a term.

[1] Cal Poly Center for Excellence in Science and Mathematics Education (http://cesame.calpoly.edu/P-16.htm)

2. Collaboration between the College of Education, College of Science and Mathematics and College of Engineering in teacher recruitment and preparation.

3. Creation of a University Center for Excellence in Science and Mathematics Education (CESaME*)* with the following goals: [2]

    - To help recruit and prepare K-12 teachers who are confident of their skills in mathematics and their understanding of the natural world, and who are dedicated to helping all children to become scientific literate citizens of the 21st Century.
    - To offer practicing K-12 teachers opportunities to enhance their knowledge of science and mathematics and to guide them to the 'best pedagogical practices" of presenting that knowledge to children and young people.
    - To explore and develop new ways of enhancing the science and mathematics learning of all students K-16, particularly less advantaged students.
    - To promote careers in Science, Mathematics, Engineering and Technology (STEM) among K-12 students.

4. Recruitment of prospective science teachers through a Teacher-Scientist model that introduces science majors to a dual career as teacher during the academic year and paid science researcher in the summer.

    Across the country, through partnerships with Federal laboratories and with major science and technology firms, science and mathematics teachers have opportunities to participate in summer laboratory research programs and enjoy an innovative career pathway in which they are both teachers and researchers.

    Sometimes called “teacher as scientist” programs, these opportunities:

    - Allow teachers to gain first hand experience in the applications of science and mathematics within applied research settings.
    - Foster inquiry-based teaching and learning strategies.
    - Foster development of learning communities in the schools and a sense of participation by science and math teachers in an extended community of scientific colleagues.
    - Include the added prestige of teachers having a joint assignment in an industry setting.
    - Provide opportunities for teachers to supplement their salaries.
    - Open the door to assistance from industry and national labs with school laboratories, including support for experiments, field trips, and guest scientists.

    There is evidence that these programs promote science and math teacher retention. For example, impressive results have been reported by Industry Initiatives for Science and Math Education (IISME), “founded in 1985 by a consortium of San Francisco Bay Area companies in partnership with the Lawrence Hall of Science at the University of California at Berkeley” to allow teachers to carry out summer projects in industry settings (See:

[2] Cal Poly Center for Excellence in Science and Mathematics Education (http://cesame.calpoly.edu/Vision.htm)

http://iisme.org/). A 2001 evaluation of the IISME program found that IISME teacher participants ("Fellows") were only half as likely to leave classroom teaching as other California teachers (Weisbaum and Huang 2001:3).

We believe that teacher scientist programs may also have a positive impact on the recruitment of science and mathematics teachers. Therefore, in collaboration with the CSU Chancellor's Office, CSU-East Bay, a number of sister CSU campuses and Lawrence Livermore National Laboratory, Cal Poly is exploring an expanded vision of the teacher scientist program concept, extending this opportunity to science majors who are prospective teachers.. We believe this pilot program's emphasis on pre-service candidates and early development of a dual career identity is perhaps unique.

A pilot Teacher Scientist project was undertaken this summer at Lawrence Livermore National Laboratory. It placed 16 outstanding science majors from four CSU campuses in research labs for paid summer research internships. Half were majors in the three areas in which the state faces the severest shortages of science teachers: physics, chemistry, and geosciences. The purpose was to enable these science majors, all of whom had a serious interest in high school teaching, to begin an innovative science career that combines teaching at the secondary grade level with paid summer research on a sustained basis.

Initial evaluation results have been highly positive. The 16 CSU students were judged as being well-prepared research team members by the mentor scientists with whom they worked. Each prepared a high quality presentation for the Lab's annual student Poster Session. The students identified a broad range of areas in which they gained significant knowledge, ranging from a conceptual understanding of the research issues explored, to a deep appreciation of the nature of scientific inquiry and an understanding of the most sophisticated equipment used in scientific research. Participants have the opportunity to participate in paid summer experience during future years. Long-term evaluation of this pilot is planned, with a design that focuses on the impacts of the laboratory research experience and the hybrid science teacher identity on the professional paths of these science majors.

STEM Outreach and Recruitment

Universities like Cal Poly have important responsibilities for outreach to parents and prospective students to encourage preparation for collegiate study. In Cal Poly's case we have particular responsibility in the State of California for fostering awareness of STEM academic and career opportunities and we have a number of programs and initiatives that work to promote wider participation by California students in these fields and disciplines. I will mention a few examples of efforts that we believe to be effective:

- Cal Poly's Admissions Office uses sophisticated targeted marketing approaches to reach out to 10th and 11th grade prospective students all across the State of California, including students from populations traditionally underrepresented in STEM academic programs. As described by James Maraviglia, Assistant Vice President for Admissions, Recruitment and

Financial Aid, methods used to communicate with these prospective applicants include "flash/video e-messages, broadcast phone messages, text messages, parent and student blogs, our new student portal, direct mail, virtual view books and telemarketing." For fall 2007 Cal Poly received a record number of undergraduate applicants for the 13th year in a row (34,173). The campus received applications from over five thousand Hispanic/Latino students, double the number received in 2000.

- During the past few years, Cal Poly has developed a special relationship with 191 "Partner" high schools, all of which have a large percentage of first generation students as well as historically low college-going rates. We help students at these schools to learn about Cal Poly and encourage them to complete the rigorous course of study necessary to be competitive in Cal Poly's admissions selection process.
- In collaboration with the California-based "Parent Institute for Quality Education" Cal Poly is bringing information about college readiness to parents of elementary and middle school students in communities traditionally underrepresented in higher education. Recently a first cohort of 160 parents of students in Guadalupe, a predominantly Hispanic central coast agricultural community, completed a nine week program that gives them skills to aid their children in preparing for college.
- With support from the University of California, Cal Poly conducts a MESA Schools Program (Mathematics, Engineering, Science, Achievement) to promote science and math success among pre-college students and awareness and participation in STEM higher education programs.
- Cal Poly student engineering association chapters participate in invaluable STEM-related outreach to diverse K-12 student populations. Examples of these student organizations include Cal Poly chapters of AISES (the American Indian Science and Engineering Society), SHPE (the Society of Hispanic Professional Engineers), NSBE (the National Society of Black Engineers), and SWE (the Society of Women Engineers).

These are just a few examples of an array of outreach efforts at Cal Poly – formal and informal – that engage students, faculty and staff in promoting awareness of STEM academic and career opportunities and encourage students to prepare for post-secondary study in these disciplines.

Potential Federal Policy Initiatives

Earlier this summer, the Business-Higher Education Forum and other members of the initiative, "Tapping America's Potential," wrote to Senators Kennedy and Enzi and Representatives Miller, McKeon, Hinojosa and Keller in support of reauthorization of the Higher Education Act (HEA), and in particular "policies that would improve U.S. science, technology, engineering and mathematics (STEM) education at all levels" (TAP 2007).

The letter urges federal policy support for efforts to:

1. *Align K-12 Education with College and Workplace Expectations*: The TAP letter advocates grants in support of state P-16 councils, as a key to strengthening the ability of schools and teachers to prepare graduates, whether they are moving into the workforce or pursuing further study. At Cal Poly we believe P-16 councils at all levels can play an extremely valuable role in ensuring that students receive early and ongoing preparation in science and

mathematics so that they may go on to pursue careers and/or advanced study in STEM fields. These councils also provide an important opportunity for business to assume a position of expanded policy leadership in support of efforts to reform and strengthen P-16 education.

2. *Recruit and Retain High Quality and Effective Math and Science Teachers*: The TAP letter echoes the recent Business-Higher Education report and other recent reports in calling for policy initiatives to "attract and retain math and science teachers and strengthen teacher preparation programs." Financial assistance for aspiring teachers, better alignment of teacher preparation with state content standards, incentives for math and science teachers to serve at "high-need schools" are among the promising measures recommended. In addition to these recommendations, I might also suggest consideration of support and incentives for expansion of Teacher Scientist programs in industry and national labs, providing laboratory research experiences starting in the pre-service phase of student preparation and extending into at least the early years of their teaching careers.

3. *Motivate Students to Study and Enter STEM Careers*: The TAP letter advocates "incentives for colleges and universities to produce more STEM graduates," including expanded support for undergraduate and graduate scholarships for STEM students and support for development of professional science master's degree programs. Along with these promising recommendations I would suggest considering additional steps to support and encourage the work of established and effective STEM outreach, recruitment and retention programs, including but not limited to programs like MESA (Mathematics, Engineering, Science, Achievement) and organizations like the National Action Council for Minorities in Engineering (NACME), AISES (the American Indian Science and Engineering Society), SHPE (the Society of Hispanic Professional Engineers), NSBE (the National Society of Black Engineers), and SWE (the Society of Women Engineers). Among the outreach initiatives that have shown particular merit and promise over the years, one might include summer campus for elementary and middle school girls, engineering summer camps and robotics competitions.

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